Pers Ubiquit Comput (2011) 15:731–742
DOI 10.1007/s00779-010-0364-y

ORIGINAL ARTICLE

A NFC-based pervasive solution for city touristic surfing

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Received: 15 March 2010 / Accepted: 30 December 2010 / Published online: 18 January 2011

Abstract Context-aware and pervasive computing applications have increased their number during the last decade, thanks to the development of new communication and mobile technologies. These applications cover a wide spectrum of problems, sectors, scenarios, and environments that aim to build smart environments supporting many kinds of human interactions. Tourism is an important economic sector for many cities and countries and therefore a research area where the development of ubiquitous applications is having a great interest. In this paper, we propose a solution oriented to help the user to find the location of interest points within the city and navigate through them. In this work, we propose the use of mobile phones with the near-field communication technology incorporated and Smart Posters disseminated along the city. Indoor and outdoor locations and navigation are allowed, "where is it?", "what is it?", "where am I?", "what is there around me?" and the remaining hits of locations and navigation paradigms are supported by an easy, cheap, and context-awareness system without the need of hard tasks to the user related to system installation or tailoring.

Keywords Near-field communication · Tourism · Pervasive system · City surfing · Ambient intelligence

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1 Introduction

The Ambient Intelligence (AmI) [1, 2] is a new investigation area that consists in the creation of living environments (called "intelligent environments") [3] where users interact in a natural and intuitive way with computational services which ease the completion of the user's everyday tasks, being this for leisure, help or work assistance [4, 5]. In these environments, the user is surrounded by ubiquitous resources embedded in augmented objects (Tags environments).

In this vision of the future that AmI forecasts, the model of user interaction, information visualization, access personalization, and context sensitivity play a very important role that has been studied by different authors [6, 7], where several models and paradigms have been proposed.

Near-field communication (NFC) [8, 9] is an emerging technology that provides a natural way of interaction between the user and their environment. This characteristic makes it the preferred candidate for the development of intelligent ambients. NFC technology is a combination of the contactless radio frequency identification technology (RFID) [10] and interconnection technologies that allows short-range wireless communication among mobile devices, PCs, and intelligent objects [11].

NFC offers a simple solution based on the "touching paradigm" [12] that makes possible the information exchange and access to content and services in an intuitive way. Besides, it simplifies people's interaction with the environment, resulting in the "Touch Computing" paradigm, where users get their mobile device close to everyday life objects, doted with visual marks and RFID Tags or other NFC devices, with the aim of triggering the intelligent services offered by those objects. Therefore, this combination of RFID and visual tagging of physical objects and NFC devices available have contributed to the

development of the "Internet-of-Things" [12] where all the resources that surround us and their associated services are available through any connection (GPRS/UMTS, Bluetooth, etc.). A possible application area of the Ambient Intelligence and the development of pervasive systems is the tourism, which is always growing.

This kind of applications are mainly oriented to two type of scenarios [13–15]: (a) indoors, as museum guides (pre-installed maps in the unit, follow-up mechanism through sensor webs (RFID) or communications (Bluetooth) localization), (b) outdoors, as pre-installed maps in the mobile unit and/or access through WLAN/GPRS to servers that provides maps or information, based or not on the user position (GPS). An example of these applications includes navigation through real traffic, transportation services, tourism guides, and commerce.

Nowadays, different investigations are studying the use of NFC in a wide spectrum of problems, including commerce, ticketing and payment, transportation, tourism, identification and security, university [16–18], among other.

Kenteris et al. [19] studied the use of mobile phones and touristic maps of the city of Mylinene. In this system, an application (MIDlet) and the maps are downloaded to the user's mobile device from a server on demand. The advantages from using J2ME for the development of pervasive applications are demonstrated, showing their adaptability to different units, services, and users.

Reilly et al. [20] studied the advantages of using paper maps augmented with RFID Tags. The user touches with his PDA one of the marked points (augmented with a RFID Tag) and gets information from the marked point through the access to a Web page. Three application scenarios are used: (a) a map of the Montreal underground, (b) a touristic map of Nottingham city, and (c) a map of the Vancouver region roads.

In [21–23], the importance of the touristic sector worldwide is revealed, introducing the services that these applications should include as follows:

- (Semantic) interoperability and mediated architectures (where it can be distinguished between the system integration and the semantics issue, related to the problem of too much information).
- E-business frameworks supporting processes across organizations—virtual organizations.
- Mobility and embedded intelligence.
- Natural multilingual interfaces (also novel interface technologies).
- Personalization and context-based services.
- Information to knowledge transformations, data mining, and knowledge management.

KAMO project [24] has as its main objective to provide information about routes and bus lines to the user, also supporting transportation payment. In this system, informative panels placed in bus stops allow the user, using his NFC device, to obtain information about public transportation schedules for the stop where the informative panel is placed. The user gets in his device the list of busses that will get to the stop where he is located and each one's destination plus the arrival time. Besides, during the trip, and in real time, the user could receive information of the bus next stop and alarms/notifications of when the user's destination will be reached. This system allows the user, when touching the informative panel in the bus stop, to identify its destination and being informed about the best line or combination for getting to its destination. Different prototypes of similar systems have been deployed in several countries' public transportation systems [23, 25, 26].

Hardy and Rukzio's proposal [23] makes use of NFC mobile phones and big screens placed in public places in a way that the information displayed in the mobile phone could be displayed in a bigger dimension. The idea is to use the mobile phone as writing and signaling object over the screen and make use of big displays to show the information in parallel with the mobile device. One of the applications presented uses a big screen that contains Tags (in its back side). Each Tag stores a string with the position inside the display. The display shows a Google map with marks referring hotels, restaurants, or other establishments in the zone shown. The user through its NFC mobile phone could look up the marks in the map, amplify them, and create routes.

In this paper, we present a touristic context-aware solution for the localization and navigation in urban environments. The idea proposed in this work is that the user could design its own routes making use of a set of intelligent objects (Smart Posters) augmented by RFID Tags with information about localizations where the tourist could go. The touristic information is shown to the user with different shapes and details; localization and surfing (navigation through different points of the scenario) is provided through real-time maps downloaded. Answers to "what is this?", "where am I?", "where it is?", "what is there nearby me?", etc. are given to the user in an intuitive and quick way, without any previous manipulation of the mobile device by the user.

The proponed solution, named CoLoSus (Contactless Location and Surfing System), is based on the use of Smart Posters with text and visual information corresponding to the places where they are located. The Smart Posters, similar as the one shown in Fig. 1, are formed by a set of Tags associated with each visual element of the Smart Poster, which offer the user different touristic locations, interesting to the tourist, within the urban environment.

The information stored in the Tags (using the NFC-Forum standard [27]), the location of the Smart Posters, the

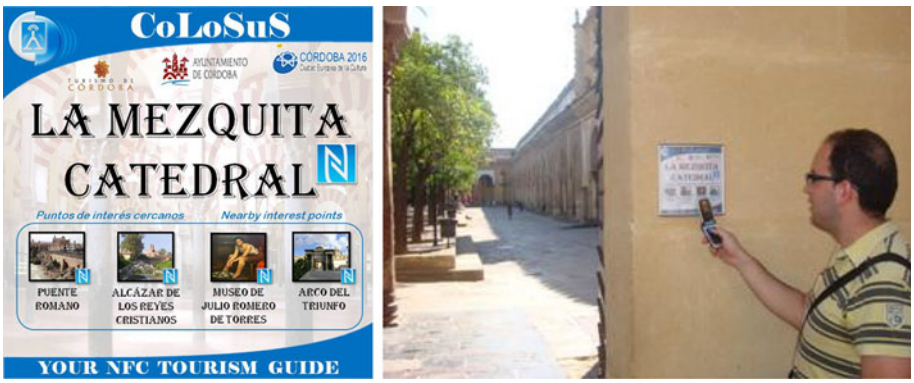

Fig. 1 An example of a Touristic Smart Poster

Fig. 2 Proposed architecture

user selection, and the information stored in the system about the previous interactions of the user with the environment would allow the system to offer, through maps and text information, a swift, quick, and user-customized channel to navigate through its environment.

The following sections of this paper describe the proposed solution. In Sect. 2, the proposed solution is presented, describing the interactive model and system architecture. In Sect. 3, the structure of the Smart Posters is described, together with the information stored in each poster and the objects in it which have a Tag associated. In Sect. 4, the tool used for developing the scenarios is detailed, and finally, an example of some of the applications carried out in urban environments is given together with a discussion about the proposed solution and future works.

2 A navigation and location model based on NFC

Current NFC mobile devices are kept to only some models from just some commercial brands. Those models do not include several of the functionalities normally available in most of the mobile devices, such as GPS. Although it has been forecasted that by 2011 more than 50% of all the mobile phones will include NFC technology, the commercial policies about how that evolution would be carried out are not yet completely defined. So, while some manufacturers are fostering the introduction of the new NFC chip in new mobile devices, others are going for external NFC solutions. For instance, SanDisk [28] is developing SD/MiniSD cards that when introduced in any mobile device will automatically provide it with the NFC functionality; TranZFinity [29] have developed an NFC device that exchange information with the mobile device through Bluetooth.

The development model of intelligent ambients applied to urban location described in this paper is based on the use of the Touch paradigm as a swift, easy, and intuitive model for helping the user to find the location of interest points in an urban environment, having a direct impact on the tourism and location in big commercial surfaces (outdoors and indoors).

Figure 2 shows the general architecture of the proposed solution. In this solution, there are Smart Posters spread in the intelligent environment containing visual, graphic, and text information about different locations. Different objects distributed in the Smart Poster that represent different locations are augmented by Tags that keep services and information about themselves.

When the user "touches" any of the Tags (objects) located in the Smart Poster with his NFC device, a MIDlet previously downloaded in the mobile device is instantiated. This MIDlet gets the information stored in the Tag and establishes a GPRS/EDGE/UMTS communication with a service located in the server.

This service gets the information from the MIDlet corresponding to the device and the Tag and moves this information to the server that answers back the MIDlet, being the MIDlet responsible for showing the answer to the user in a proper way.

For our navigation and urban location model, the server required is a map and route generator from the information stored in the Tag. Therefore, the MIDlet will obtain that

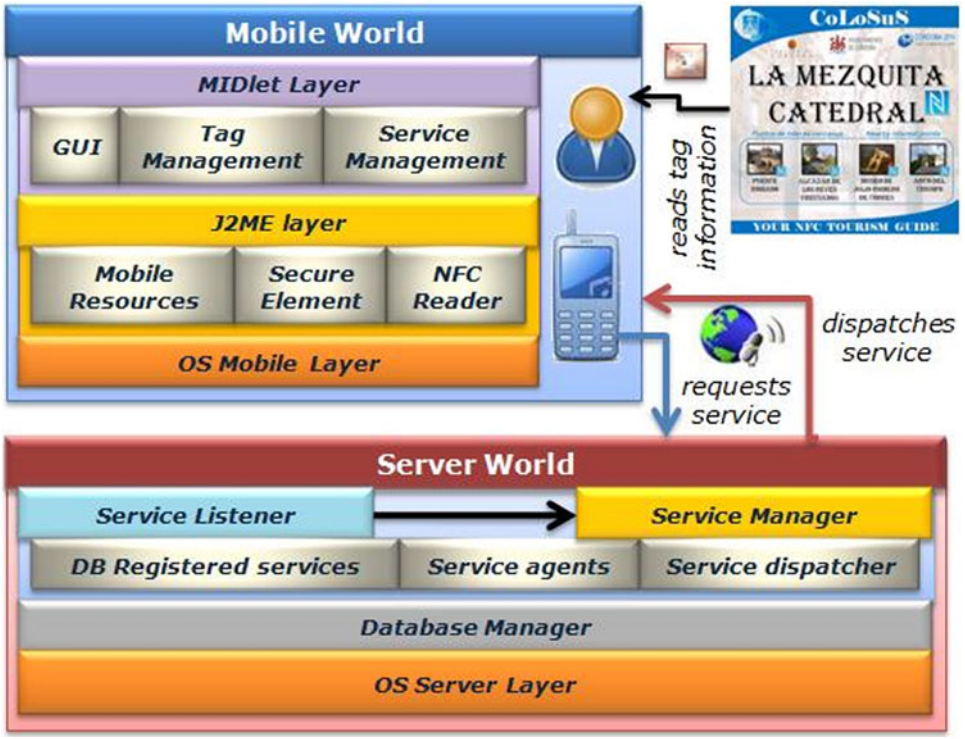

Fig. 3 Surfing model components

information from the Tag and will send it through GPRS/UMTS to a services server. The services server will get the information corresponding to the Tag, the NFC device, and any other supplied by the MIDlet; then it will generate the requested information and will send it back to the MIDlet, which is in charge of formatting that information in a proper way.

As observed in Fig. 3, the functional components in the interaction model are five: (a) the scenario, (b) the Tags, (c) the MIDlet, (d) the service listener, and (e) the service manager.

The scenario is comprised of a set of Smart Posters with information and pictograms about the following:

- The location, place of interest where the Smart Poster is located.
- A set of locations for the points of interest suggested, which are related, within the application context, with the current location and are adequate to the user.

The Tags are Mifare 4K [30] Tags associated with each one of the pictograms in the Smart Posters. The Tags store text and graphic information related to the object and pictogram; they are associated with the service or set of services offered to the user and recognized by the MIDlet installed in the mobile device when the user gets its NFC device close to the Tag.

The MIDlet is a Java application that is executed in the NFC device and that guides the interaction between the user and the scenario. When the user "touches" a Tag with its NFC device, thanks to the information stored in the Tag, the MIDlet stored in the mobile device is instantiated allowing the interaction of the system with the user. This event is carried out thanks to the "push registry" method. Through the "push registry" method, the mobile phone would activate a specific MIDlet depending on the kind of information that has been read in the Tag.

When the MIDlet has not been previously installed in the NFC device, a message alerting about the need of downloading the MIDlet from the server is received. Once the MIDlet is downloaded and installed in the device, the user can configure it.

As shown in Fig. 3, once the information from the Tag is received, the MIDlet creates the interface which drives the interaction with the user. The user can visualize the information received from the Tag and choose the desired service among the ones offered by the Tag.

Services have been implemented using the NFC business platform developed by Nexperts [31]. The development and implementation of each service was not a trivial process. The procedures were implemented using C# language and compiled for obtaining the server application. Then, each service application was executed on an external tool called "Proxy Generator" with two purposes: (a) installing the DLL in the Windows assembly of server (install the server service) and (b) generating a proxy file in Java that handles the network traffic for the client application providing several functions that could be instantiated by the MIDlet and which goal was to establish a

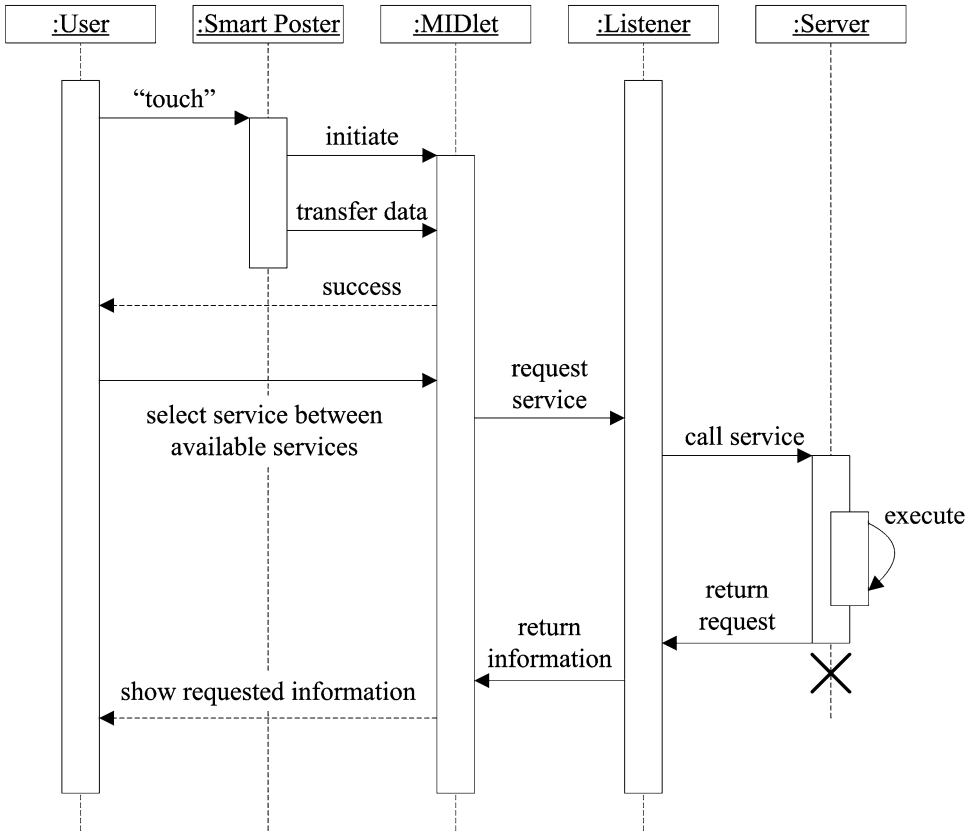

Fig. 4 Sequence diagram of the system components interaction

reliable and secure bidirectional communication between the MIDlet installed in the phone and the service dispatcher. Hence, the MIDlet is composed by two main packages: (a) the application code developed specifically by the client and (b) the proxy object generated by the proxy generator. Once compiled and generated the final application, it must be installed in the devices. For this purpose, we have used the Nexperts Business Platform [31] because it allows the deployment of a signed MIDlet to the user's mobile phone using the OTA (Over the Air) Deployment module by WAP Push or by starting the download from a Tag.

Figure 4 shows the sequential diagram corresponding to the interaction process among the system's components. Once the service is selected, the request is sent through the communication modules of the mobile phone (GSM/GPRS/UMTS/EDGE) to the system server side. In that side, a service server that is listening would receive the request and process it.

The service listener is an agent located in the services server in charge of receiving any request from the MIDlet executed in the NFC device. The MIDlet requests could be the following: (a) information or services about an interest point and (b) a map or location route of a certain point of interest.

When the service listener receives a request, it analyzes it, checks its registry, and processes it to the Service Manager, who is responsible to execute it and sends back a response to the MIDlet, being the MIDlet the one in charge of formatting it into a proper display to the user and offer him the programmed functionality for the handling of the information received.

Both the listening service and the service server have been implemented making use of the NFC Business Platform from Nexperts. The NFC Business Platform is software created for the developing, use, and integration of business functions for NFC-based applications. Through this software, clients (mobile phones or computers) are connected to the server through GSM/GPRS which is the one that controls them and provides the proper service to each client. The mobile device transfers the information received from the Tag or generated by the MIDlet to the server, which is in charge of processing the request and answer the MIDlet. In case of a temporal connection failure, the server would keep the answer to the requested service server, being it send only when the connection is recovered.

3 Smart Posters' structure

As mentioned previously, the operation scenario is an open and intelligent environment thanks to the Smart Posters spread through it where there are objects with visual

information and Tags associated. Each object would represent a specific location, a touristic interest point, a company, or any other location within the application scenario.

The user will met the Smart Poster where, at first sight, he will see the name assigned to it (the place, location, interest point, etc., where it is placed) and where, through icons, pictures or any other text, and visual information in the Smart Poster, other interest points or locations within the environment are placed. Main role of those Smart Posters is to:

- Allow the user to access the available information and services in a touristic information service, related to (a) the point of interest where the Smart Poster is located and (b) any of the other points of interest or locations showed in the Smart Poster.
- Display different options to the user (any different icon/picture/object listed in the Smart Poster) in order to get information about it, led to it and, therefore, locate it from a Smart Poster placement.

So, in a Smart Poster, the existence of the following kinds of objects could be recognized, being those objects displayed in a visual and textual way: (a) a sole object (CP: current point) corresponding to the location or point of interest where the Smart Poster is located and (b) a set of objects related to the "suggestions" (AP: Advance Points) displayed to the user about other interest points or locations within the scenario.

Each Tag related to an object in the Smart Poster has a unique identifier (TUID), as each interest point or location (LUID) independently of the Smart Poster where it is located. One or more Smart Posters can, clearly, include the same location which would allow the user to find different location routes within the scenario depending on the location or starting point.

Besides, each Tag (a Tag is related to a unique interest point: CP or AP) stores the following information:

- A description corresponding to the name of the interest point or location.
- A brief description of the interest point related to the Tag.
- A picture (icon) corresponding with the interest point (CP/AP).
- Physical coordinates where the Smart Poster is placed.
- Physical coordinates of the interest point related to the Tag.
- A set of locations, in case they exist, or "intermediate" interest points in the route from the location of the Smart Poster to the suggested interest point (AP).

3.1 Tool for Smart Posters developing

A Java application for the development of the scenarios handled by the CoLoSuS system (contactless location and surfing system) has been developed. The tool allows the developing of Smart Posters where a non-defined number of Tags will be located; those Tags would be related to some visual objects that would display points of interest within the environment for guiding the user through the urban navigation or surfing.

Figure 5 shows a snapshot of the general interface of the application. As can be perceived, the general interface is divided into a toolbar and a menu, the project explorer zone that would allow the handling of the information about the Smart Posters previously created, the working zone where the information about the Smart Posters is displayed, and a zone for messages and alerts occurred during the application execution together with a status bar.

The menu bar shows the available options for the application. Through this bar, it is possible to create new scenarios (Smart Posters) and Tags and also to manipulate the information related to them, as well as to perform the recording of the Tags in Mifare cards for placing them afterward in the objects that display the interest points.

Besides, as shown in the upper zone of the interface, there is a quick access bar that allows the quick execution of the functionality more used by the user. The most significant zone of the interface is displayed in the explorer zone (left area) and the working area (central area), as shown in Fig. 5.

The project explorer displays, in a hierarchic menu structure, the currently active information in the application, which it includes the set of Smart Posters and their associated Tags. The working area allows the display and edit of the information related to the Tags and Smart Posters.

All the error, information, warning, and exception messages are displayed in a frame defined for that purpose and placed at the bottom of the working area. The purpose of this frame is to show the user all the different actions that are being executed and their result during the handling process of the scenarios and projects.

The tool groups the information under the concept of scenarios or projects. Each project could be composed by a non-defined number of Smart Posters, and each one has also a non-defined number of Tags associated with it.

Once the project has been created or an existing one has been opened, the information about the project components (Smart Posters and Tags) is displayed in the hierarchic menu (See Fig. 5). The user can create or edit Smart Posters of the scenario, using the interface shown in Fig. 6a.

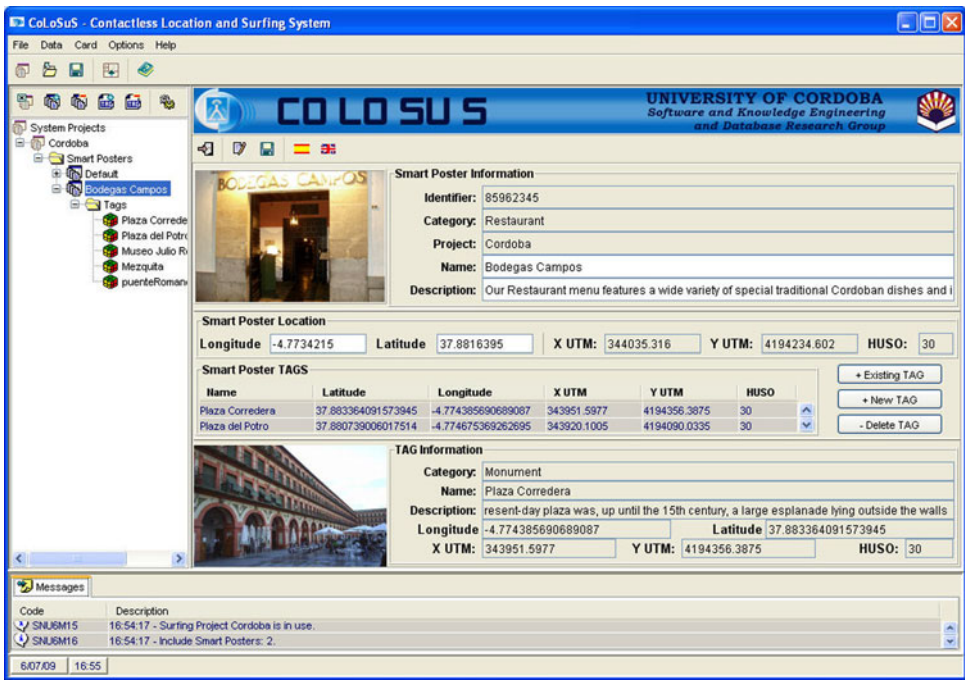

Fig. 5 Snapshot of the application interface

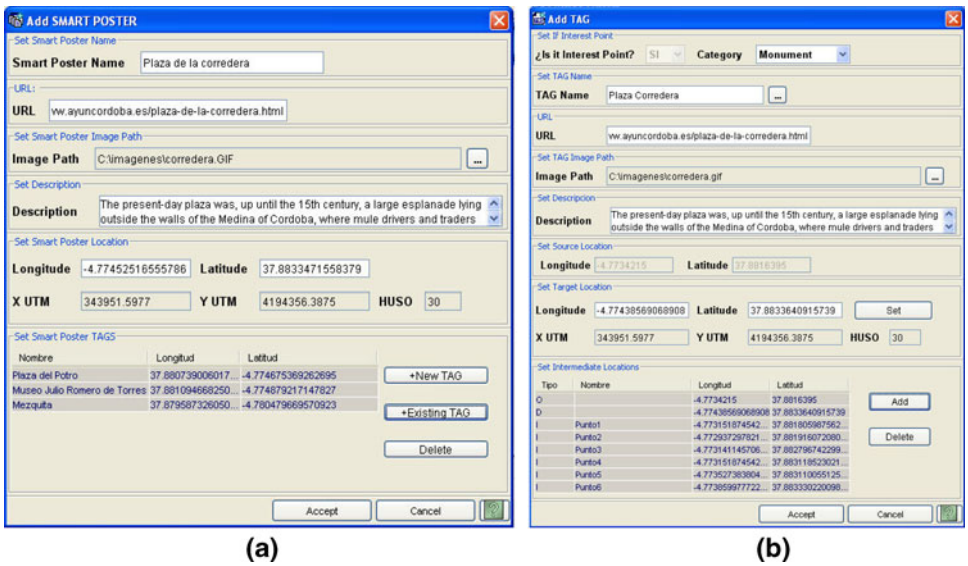

Fig. 6 Snapshot of some dialog boxes: **a** add Smart Poster, **b** add Tag

For each Smart Poster, the user could decide a non-defined number of Tags that will be related to the pictograms of the Smart Poster. Each Tag will store information and services corresponding to the AP (advice points) available in the Smart Poster. For performing this function, the user will fill in the information as shown in Fig. 6b, selecting it from existing APs or creating new ones. The information related to the Tags created for each Smart Poster could be displayed as a list and being accessed for edition at any time (see Fig. 6b).

The user, making use of the "Store Tags" function available in the main menu of the application, can, at any time, carry out the recording of the different Tags associated with the Smart Posters. This recording process could be performed for a Tag or for the set of Tags in the Smart Poster. Once recorded, the information related to the UID of the Tag associated with each Smart Poster is also stored in the database.

4 CoLoSuS MIDlet

The CoLoSus MIDlet is a Java application for a NFC device, in our case a mobile phone. The tool allows getting

Fig. 7 Some MIDlet snapshots

information about a point of interest through Smart Posters that contain visual objects with a NFC Tag assigned to them, which stores the information about the point of interest.

Figure 7 shows a snapshot of the application's interface. The MIDlet could be instantiated on demand by the user (Fig. 7a) or automatically (Fig. 7b) when the user "touches" a Tag available in the Smart Poster.

As shown in Fig. 7a, if the MIDlet is instantiated on demand, the application shows to the user all the available options: (a) Browse information, (b) Configuration, (c) Delete history, (d) Recover information, (e) Recover map, (f) Search, and g) Touch Tag.

The information (maps and text) received by the user in previous interactions with Smart Posters could be stored for future accesses and requests. This information is stored in the mobile device, being the location chosen by the user in the "Configuration" options (Fig. 7c). The user could at any time, manually or guided by the MIDlet, delete the historical information stored in the device.

The system allows the user, without the need of touching a Tag, to make different requests about points of interest located in his environment. During the search process (see Fig. 7d), the MIDlet allows the user to include some optional search criteria: (a) category or type of the interest point, (b) name or search criteria, and (c) distance from the current location.

Once the search criteria have been chosen, the MIDlet sends the request to the server that answers back a map and a list with the current location of the points of interest that fulfill the current search criteria.

As the system does not use a GPS for knowing the current location of the user when the request is performed, the position of the last Smart Poster accessed by the user would be considered as the current position, being marked in the generated map. Figure 7e, f show the resulting map and the list of interest points for the search criteria selected in Fig. 7d.

When a Tag in a Smart Poster is "touched" with the NFC device (Fig. 7b), the MIDlet is initiated (if it has not been previously by the user) and it guides the user through the interaction, informing about the services stored in the Tag. As shown in Fig. 7b, in the current MIDlet implementation, three options could be selected by the user: (a) a

Fig. 8 Smart Poster Tags touch process

short description of the interest point, (b) Web access, and (c) map download.

The information of the short description about the point of interest (Fig. 8a) is stored in the Tag, and there is no need to connect to the server to obtain it.

Each Tag stores a Web address that could be accessed by the user, with detailed information about the corresponding point of interest. In this case, the user accesses to a Web page with detailed information about the interest point (Fig. 8b).

Finally, the user can download a map with the location of the point of interest selected (Fig. 8c). This map shows the user's current location, the point of interest location, and the route to get to it. The locations visited previously by the user are marked, meaning this, the places where the Tag corresponding to a Smart Poster was touched. This information is temporarily stored (until the user deletes the history). Besides, different options in the MIDlet allow the user to handle the map image and store it for later requests.

5 Test scenarios

The system was tested in two different scenarios pretending to demonstrate the application of the test solution. The first scenario covers a touristic area in Cordoba city and its development has tried to propose to the city majors its future use, as an initiative if Cordoba is named in 2016 Worldwide Culture City. The second scenario aims to demonstrate its commercial use for the navigation and location of companies in large commercial areas.

For the development of the Smart Posters Tags, Mifare 4k [30] and Omnikey 5120 USB [32] have been used as read/write device. The NFC devices used have been Nokia 6131 NFC [33] mobile phones.

5.1 Cordoba's historic center

For the development of this scenario, a set of Smart Posters as the one shown in Fig. 1 has been built and placed in different points of interest within the selected tourism area. Each Smart Poster holds a Tag corresponding to the location where it is placed plus another set of Tags corresponding to other interest points suggested, which are marked in the Smart Poster through a picture. Production costs for each Smart Poster are low (about 20 Euros).

The first time a user "touches" a Tag with his NFC device, the system detects that the MIDlet is not installed in the NFC device, and it asks the user whether he wants it to be downloaded or not. Once the user has the MIDlet installed, it can configure its execution. The user can surf among different touristic interest points within the historic center of Cordoba just touching the image of any of the suggested points of interest available in the Smart Posters. Figure 9a shows how a user located in the "Alcazar de los Reyes Cristianos" touches the Smart Poster in order to obtain information about the "Mezquita Catedral". A map with the suggested route, the intermediate points of interest between the current location and the destination, is downloaded to the mobile device (Fig. 9b).

After the monument has been visited, the user asks for information about the "Julio Romero Museum" touching the corresponding picture in the Smart poster located in the monument visited (Fig. 9c, d). However, the user might decide to have lunch, and using the MIDlet, it could make a search for restaurants in the area nearby (Fig. 9e); when the search is completed, a map (Fig. 9f) and text information is received in the mobile device.

Once the user has had lunch in the "Bodegas Campos" restaurant, the user might decide to visit "La Plaza de la Corredera" and touching its corresponding picture in the Smart Poster located close to the restaurant (Fig. 9g), she

Fig. 9 Tourism in Córdoba using CoLoSuS

Fig. 10 Use of CoLoSus in outdoor commercial areas

gets the new route for the new monument. A Smart Poster located at the restaurant would allow the user to continue with his/her personalized touristic visit to Cordoba.

5.2 City business area

Business or commercial areas of a city are normally large commercial areas located outside the city center where the companies are placed in big commercial spaces. Those commercial areas where several companies are placed use to be badly signaled, there is also a lack of information about them in city maps and the users have big difficulties to locate the companies they are searching for. The use of Smart Posters could be an opening move that favors the business in those commercial areas, helping to locate the companies and easing the flowing of users to them.

The test scenario chosen has been the biggest industrial area in Córdoba city, named "Las Quemadas". In this scenario, different Smart Posters have been placed (see Fig. 10) where there is information about the companies located near the Smart Poster.

When the user "touches" the icon of a company (area of the Smart Poster dedicated to the company), he could get the map, a short description of the company (where there is a contact number and detailed address), or access to the Web page of the company. If the company the user looks for is not in the Smart Poster, the user can make a search about it or "touch" a specific icon in the Smart Poster that provides him a map with the location of the different information points (Posters) located in the area.

5.3 System's evaluation by users

For several days, a system testing evaluation was carried out in the historical and touristic area of Cordoba city. The users were randomly chosen among the people that

Table 1 Results of users' experience with the systems

	<18		18–30		30–40		40–50		50–60		>60		Total
	M	F	M	F	M	F	M	F	M	F	M	F	
People	5	7	12	15	7	9	11	11	8	9	5	10	109
Q1	4.8	4.3	4.7	4.3	4.7	4.4	4.3	4.6	4.4	4.7	4.6	4.2	4.5
Q2	5.0	4.7	4.7	4.6	4.6	4.7	4.6	4.5	4.4	4.6	4.0	4.2	4.6
Q3	4.2	4.1	3.9	4.0	3.9	4.0	4.3	3.8	3.9	4.2	3.8	3.4	4.0
Q4	4.8	4.4	4.4	4.5	4.4	4.4	4.9	4.4	4.5	4.2	4.4	4.2	4.5
Q5	4.8	4.6	4.5	4.7	4.7	4.7	4.4	4.6	4.6	4.6	4.0	4.4	4.6
Q6	4.6	4.7	4.5	4.6	4.4	4.4	4.7	4.3	4.5	4.6	3.8	4.0	4.4
Q7	3.2	3.7	4.1	3.8	4.1	3.8	4.0	3.7	4.0	4.3	3.4	3.5	3.8
Q8	4.8	4.3	4.4	4.2	4.4	4.2	4.4	4.4	4.3	4.8	4.2	3.9	4.4
Average	4.5	4.4	4.4	4.3	4.4	4.3	4.5	4.3	4.3	4.5	4.0	3.9	4.4

willingly decided to take part in the experience. As the participants did not know the NFC technology, they were provided with a brief explanation (2–3 min) of its characteristics, the capabilities of a NFC mobile, and its operation. Then, the NFC device was offered to the participants for interacting with any of the icons (services) of the Smart Poster.

Once finished the user interaction and solved all the doubts raised by the users (the most usual was whether the mobile phone owned by the user had the capabilities of the NFC device used during the experience), they had to answer a small survey related to the experience. The survey had the following eight questions that have to be evaluated between 1 (very low) and 5 (very high):

- Q1 The system is easy to user.
- Q2 I think that the deployment of this type of systems would be useful.
- Q3 I will use the system when deployed.
- Q4 The system helps me to navigate through the urban environment.
- Q5 I consider a good idea the use of my mobile device as touristic guide.
- Q6 I consider that this is a good alternative for substituting the current access model to the touristic information: maps, guides, etc.
- Q7 I am pleased with the cost that the use of the system will imply.
- Q8 Global valuation of the CoLoSus system.

Table 1 shows the results obtained, distributed by age and sex for a set of 109 users surveyed. As can be observed in the results, all the users considered the system as very easy to use (Q1) as well as useful when deployed (Q2); the users were in favor of its use as help in the urban surfing through the mobile device (Q3, Q4, Q5, Q6).

Participants gave a very favorable evaluation to the system (Q8); the lower mark given by the users was to question Q7. Although the deployment of the system is quite cheap, some participants had doubts due to the high price of the mobile data traffic of the telecom operators in Spain, being more reluctant those users in an age range where the purchasing power is lower (under 18 and over 60).

As can be observed in Table 1, the results do not show considerable deviations between sexes in the same age range, neither for participants under 60 years. Participants over 60 years (15) were those who valuated lower the experience, which can be explained by the technological handicap that could exist for some of those participants.

6 Discussion and remarks

In this paper, we have presented a generalized system for surfing in urban areas and for location of points of interest making use of near-field communication technology. The system is cheap and easy to be set up, without needing any special device (generally, the devices could be hired in any Tourist Center Point). The user just needs a single NFC-enabled phone for interacting with the set of Smart Posters spread along the city area considered, which have cheap Tags associated with pictures of the points of interest, therefore offering the user information and personalized surfing services through maps and text information.

The system developed does not require any configuration by the user, or he is going to any Tourist Information Points or any tourist Web portal access in order to get the system downloaded. First time the user "touches" a Tag in a Smart Poster, the MIDlet is downloaded to the device and the user just have to choose the language for interacting with the service.

The combination of an intuitive paradigm for the interaction with the user (touching paradigm), the use of

clear and simple interfaces in order to avoid screen limitations in mobile devices, and the functionality of the developed system offers the user all the requested services for the fulfillment of basic requisites of an ubiquitous system: where am I, what is this, how can I get to, where can I find something, what amenities are close to this place, etc., through text information and maps.

The results of the system testing performed have reported a quite favorable evaluation by the users. Users have assessed very positively the simplicity of its use and the help that the system provides for surfing in urban environments, finding quite attractive that they just need their mobile device, as a support or alternative to traditional techniques.

Currently, CoLoSus is an operating prototype that is being proposed for the study of its near deployment. Cities implicitly touristic as Cordoba (applicant to be European Culture Capital in 2016) and others within Spain and the world would require systems as the one described in this paper in order to provide its touristic offer with extra added value, given the social and economic impact of the tourism revenue in those kinds of cities.

Besides, CoLoSus could be deployed with other commercial purposes. Its deployment in big commercial areas, where the user has trouble with the location of the companies located there, could underpin an increase and expansion of the business in those areas.

Acknowledgments This work was supported by the Ministry of Science and Innovation of Spain (MICINN) and FEDER (Project: TIN2009-07184).

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